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Rice Cropping Patterns in Southern Asian Delta

by

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Abstract

This paper aims at finding a set of correlations possibly existing between rice cropping patterns and land forms of deltaic regions in Southern Asia where rice is planted. The Ganges-Brahmaputra, Chao Phraya, Mekong and Songkoi deltas are studied. Land forms are schematically categorized into six types, viz., Flood Releasing Area, Old Delta, Floodplain, Young Delta, Coastal Zone and Local Swale (Fig. 15). Five rice cropping patterns are distinguished, viz., Transplanted monsoon rice single cropping, Broadcast monsoon rice single cropping, Post-monsoon rice single cropping, Pre-monsoon rice single cropping and Double rice cropping (Fig. 14). The following correlations are obtained:

- 1) Transplanted monsoon rice single cropping is practiced in such well drained area as Flood Releasing Area, Coastal Zone and the higher level of Old Delta;
- 2) Broadcast monsoon rice single cropping is adopted in such poorly drained area as Floodplain, the lower level of Old Delta and the most part of Young Delta;
- 3) Post-monsoon rice single cropping is found in such flood accumulating area as Local Swale;
- 4) Pre-monsoon rice single cropping occurs forming patches in those plots where either irrigation facilities or natural moisture is available during the early monsoon period;
- 5) Double rice cropping is practiced on areas where water control is possible with irrigation and/or drainage installations, regardless the physiographic units.

Introduction

To find out correlations possibly existing between rice cropping patterns and land forms, four major deltas of Southern Asia, viz., Ganges-Brahmaputra, Chao Phraya, Mekong and Songkoi, are studied. In the first chapter, the existing cropping patterns and land forms are described, whereas in the second chapter, they are schematized into a delta model. In the third chapter, possible correlations are given. The Irrawaddy delta is omitted from the discussion due to the insufficiency of data, though it is one of the major deltas of Southern Asia.

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I Description

Land forms and rice cropping patterns in four deltas, the Ganges-Brahmaputra, Chao Phraya, Mekong and Songkoi deltas are described below.

I-1 Ganges-Brahmaputra delta

I-1-i Land form

The physiographic division of the Ganges-Brahmaputra delta and its adjoining areas is shown in Fig. 1. This map is prepared by the present author based upon his own field observations and upon informations obtained through existing maps on physiography and

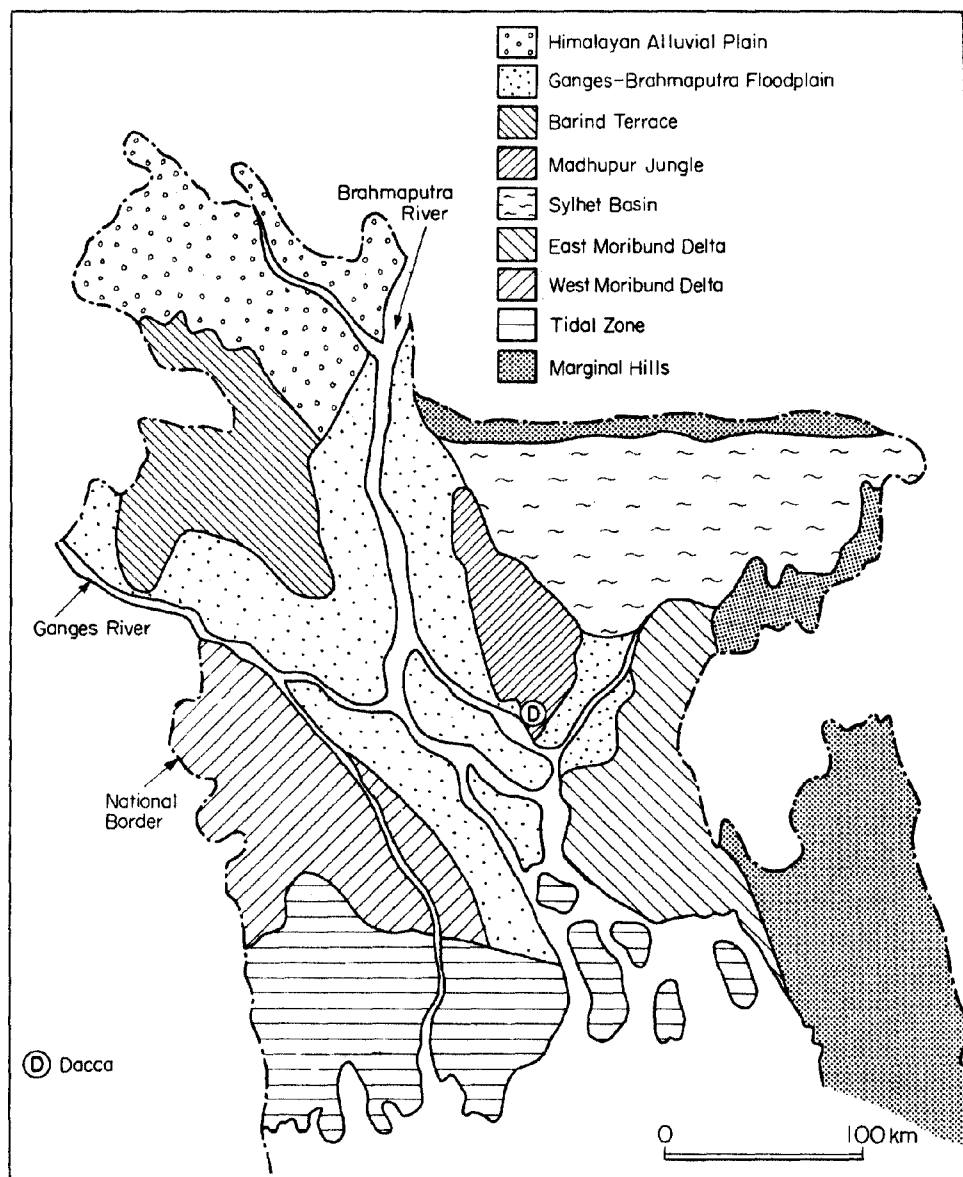


Fig. 1 The physiography of the Ganges-Brahmaputra delta (Bangladesh)

soil of the region.^{1,2,3)} The region is divided into nine physiographic divisions, viz., Ganges-Brahmaputra Floodplain, Sylhet Basin, Tidal Zone, West Moribund Delta, East Moribund Delta, Himalayan Alluvial Plain, Barind Terrace, Madhupur Jungle and Marginal Hills. The character of each division is briefly described below.

Ganges-Brahmaputra Floodplain

The floodplain is composed of natural levees and backswamps. The levees stand above flood water all through the year, while the backswamps submerge under the annual monsoonal floods for several months and dry up during the subsequent dry season. These soils are composed of clay and loam.

Sylhet Basin

This is located about 300 km inland from the sea, but it lies in many parts lower than 3 m above sea level. The abnormally low elevation of the area is attributed to a geotectonic subsidence.⁴⁾ The basin receives enormous run-off from the Assam hill to the north which is a world famous perhumid region. To cope with the huge volume of the run-off, the basin has only one narrow outlet at its southeastern corner, suffering from immense flood in every monsoon season. Even during the dry season many places remain as ponds or lakes because of the poor drainability of the basin.

Tidal Zone

Levees and backswamps diminish in this area, and the ground surface becomes flat. Monsoon floods come gently and cover the entire area moderately for several months during the monsoon season. The characteristic of the area is the effects of tide; tidal bores sometimes come with the rising tide 4 to 5 m high in the Meghna estuary, cyclones cause frequently extensive salt water inundation with loss of lives and properties. Even normal tides bring salt water into many places during dry season. According to Brammer,²⁾ the area is further divided into two units, i.e. saline tidal zone and freshwater tidal zone. The former corresponds to the so-called *sundarban*, while the latter represents the mouth of the Meghna river.

West Moribund Delta

This is believed to be an abandoned part of the Ganges-Brahmaputra Delta. The surface with the web of levees and backswamps is not so flat as that of Tidal Zone. Because of the unevenness of the ground surface, it forms a mosaic of deeply flooded and shallowly flooded plots when the area is flooded. But the drainability of the area is fairly good, owing to a considerably general slope. During the dry season, most area dries up. The soils are clay or loam.

East Moribund Delta

This is supposed to be a tectonically uplifted deltaic plain of the early Recent age.⁴⁾ Since it is uplifted about 2 m from the adjoining Ganges-Brahmaputra floodplain, the drainability is fairly good, although moderately flooded during the flood season. The drainage system

of this area is well developed with rectangular pattern of man-made canals in contrast to the braiding and meandering channel patterns of the adjoining Ganges-Brahmaputra Floodplain and Tidal Zone.⁴⁾ Soils are fresh and fertile.

Himalayan Alluvial Plain

This is an area covered by alluvial fans of the Tista and its equivalents which come down from the Himalayan foot hills. Because of a complex of old and young alluvial fans, the topography and soil conditions are complicated. Flat lands and relieved lands occur side by side, and sandy soils and clayey soils make a mosaic. During the flood season, some parts inundate deeply for a prolonged period, while in others shallow inundations remain for short period. From the large catchment area of the Himalayan hills water is supplied abundantly.

Barind Terrace

This is an area composed of terraces of Pleistocene age. The terrace surface is slightly undulating and incised by entrenching stream valleys. The terrace surface is flooded only shallowly for a short period even in the rainy season and dries up completely when the dry season arrives. Soils on the terrace are composed of poor soils of pale reddish color with numerous iron concretions. Since entrenching valleys receive run off from surrounding terrace surfaces, they are flooded very rapidly and deeply and deep water for a long time.

Madhupur Jungle

This is also supposed to be a Pleistocene land covered by lateritic type soils^{2,4)} with the ground surface more uneven than that of Barind Terrace. Most slopes are too steep and too poorly watered to be used for agricultural purpose. Only entrenching valleys have a flat and fertile ground surface. Those low-lying zones of the Jungle are, however, a flood accumulating area and not suitable for agriculture because the flood water comes too rapidly and is too deep.

Hills and Mountains

These are composed of Tertiary and older rocks. Most areas are covered by forests and some are utilized by shifting cultivators. Paddy growing is seen in stream valleys only.

I-1-ii Rice cropping patterns

There are four predominant rice cropping patterns in the Ganges-Brahmaputra deltaic region; they are broadcast Aman single cropping, Boro single cropping, transplanted Aman single cropping, and Aus single cropping. Their calendars and respective distributions as of 1970 are shown in Figs. 2 and 3.

Broadcast Aman single cropping

This is practiced in most part of Ganges-Brahmaputra Floodplain and of the medium level of Sylhet Basin. Seeds are sown broadcast, after ploughing up, on a non-waterlogged land in very early part of the rainy season. They are left to take their chance of surviving

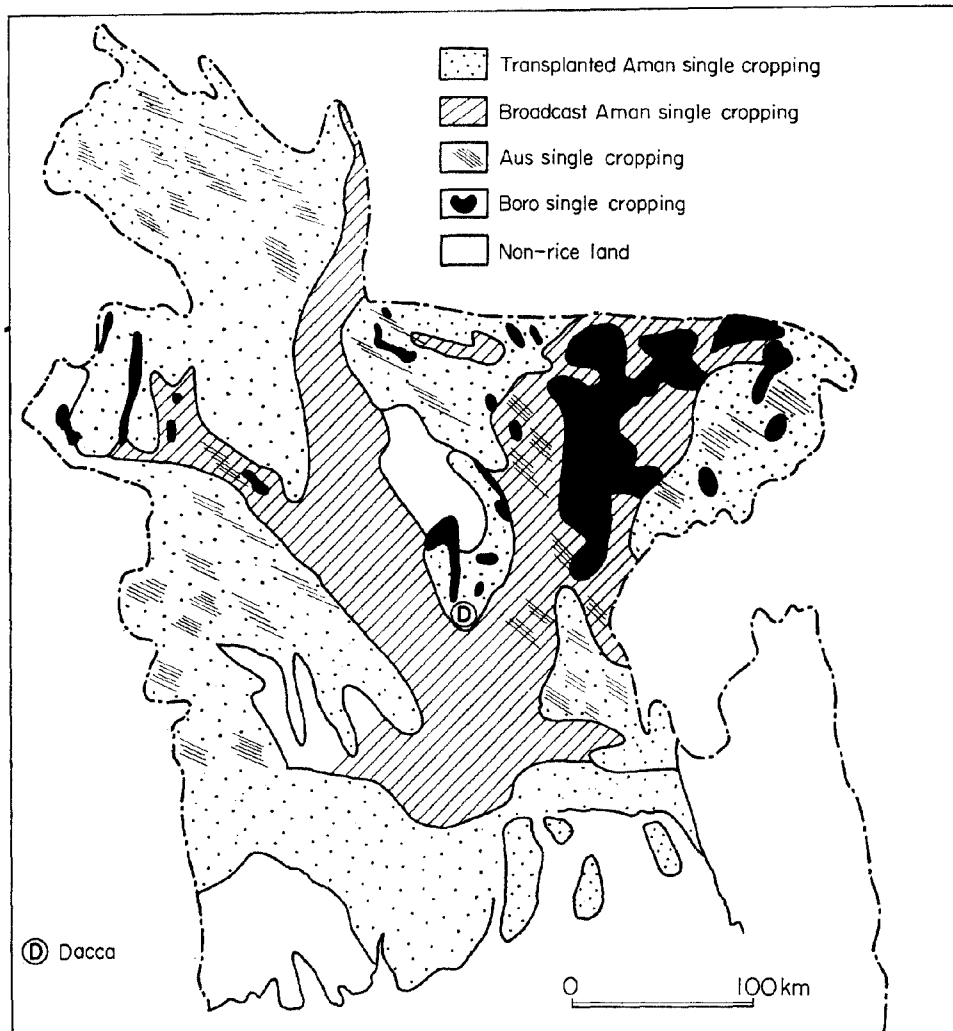


Fig. 2 Rice cropping patterns in the Ganges-Brahmaputra delta (Bangladesh)

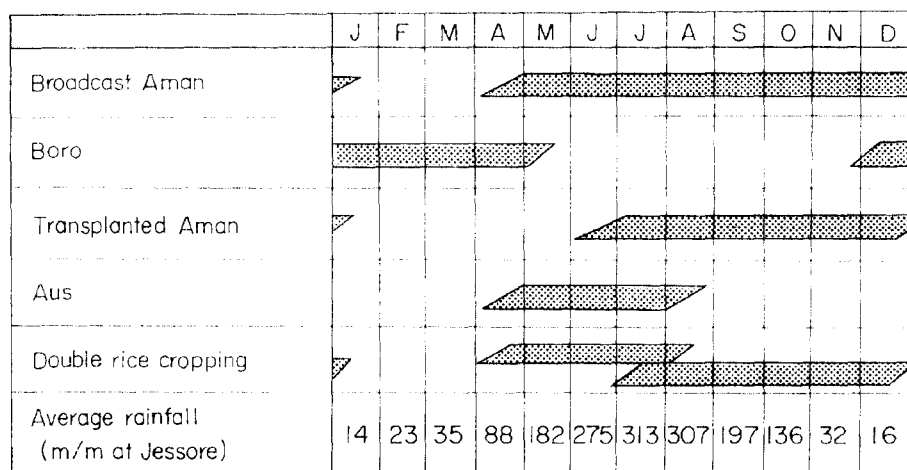


Fig. 3 Rice cropping calendar in the Ganges-Brahmaputra delta (Bangladesh)

floods. Once flood water comes there is no way of controlling it; floods may become as deep as 3 m. Some Aman, like *Bawa* which is grown in very low-lying area, grows as tall as 5 m. Harvesting is done during November and December when the floods recede. Broadcast Aman is sometimes grown with the low land Aus as a mixed crop. In this case the Aus is harvested earlier leaving the Aman crop in the field.³⁾ After the harvest of the Aman rice, the lands are left idle until the next rainy season.

Boro single cropping

Boro is most commonly found in the low level of the Sylhet Basin. Smaller distributions are found along trenching valleys in the Barind Terrace and the Madhupur Jungle. These places are so rapidly and so deeply submerged under the monsoon flood that no rice variety can survive. Thus the only way to utilize the lands is to grow rice by avoiding the flood. Boro is usually planted around the edge of slowly drying pools and streams about the time when the Aman rice is becoming ripe. The production of this crop depends on irrigation; where the water supply is adequate the outturn shall be excellent.

Transplanted Aman single cropping

This is the most popular cropping pattern in the deltaic region. Transplanted Aman are typically seen in Himalayan Alluvial Plain, Tidal Zone and the high levels of Barind Terrace and West Moribund Delta. In East Moribund Delta Aman is mixed with Aus varieties. Transplanting is mostly done in August, and the harvesting lasts over a period from November to January depending on the drainability of the area. The harvest is early in a well drained area, while the late harvest is common in a poorly drained area.

Aus single cropping

Aus rice is cultivated in an area of about one fourth of the total rice land of Bangladesh.³⁾ As mentioned above, Aus fields are found side by side with transplanted and broadcast Aman fields. Many kinds of land form can afford to have Aus. The requirement for growing Aus is either irrigation facilities or natural moisture during pre-monsoon period. Seeds are mostly sown broadcast, though transplanting may be done in very poorly drained plots. There are two kinds of Aus; high land Aus and low land Aus. High land Aus is sown in April and May and harvested in July and August. Low land Aus is started in February and March and harvested in August and September when the fields are under water. High land rice comprises the absolutely dominant portion of Aus crop.

Double rice cropping

In some well watered fields whose water levels are controlled by polder dikes, two rice cropping is adopted. Aus is grown first and then followed by transplanted Aman. This is seen in scattered areas in East Moribund Delta, West Moribund Delta and the marginal parts of Ganges-Brahmaputra Floodplain.

I-2 Chao Phraya Delta

I-2-i Land form

A physiographic map of the Chao Phraya deltaic region is shown in Fig. 4. This is prepared based on a physiographic map previously published by the same author.⁶⁾ The characters of seven physiographic units shown in the map are described briefly below.

Delta Flat

This comprises the main portion of the Chao Phraya delta. The ground surface is in most places around 2 m above sea level and is very flat-lying. This dries up during the dry season but submerges under flood with depths of 0.3 to 1 m during the rainy season. Soils are mostly composed of clay, and acid sulphate soils occasionally occur.

Riverine Delta Flat

This occurs at merging portions between Delta Flat and the mouths of such big rivers as the Chao Phraya, Suphan Buri, Pasak and Mae Khlong. The topographic as well as hydrographic natures differ distinctively from those of Delta Flat. Topographically the ground surfaces show unevenness with levees. Hydrographically this is more intensely flooded than Delta Flat due to the quick accumulation of inflow from upper streams. Floods easily become as deep as 3 m in depressional portions and stay there for a prolonged period. During the dry season most parts of the area, however, dry up leaving scattered swamps and pools. The demarcation between Delta Flat and Riverine Delta Flat on Fig. 4 is drawn

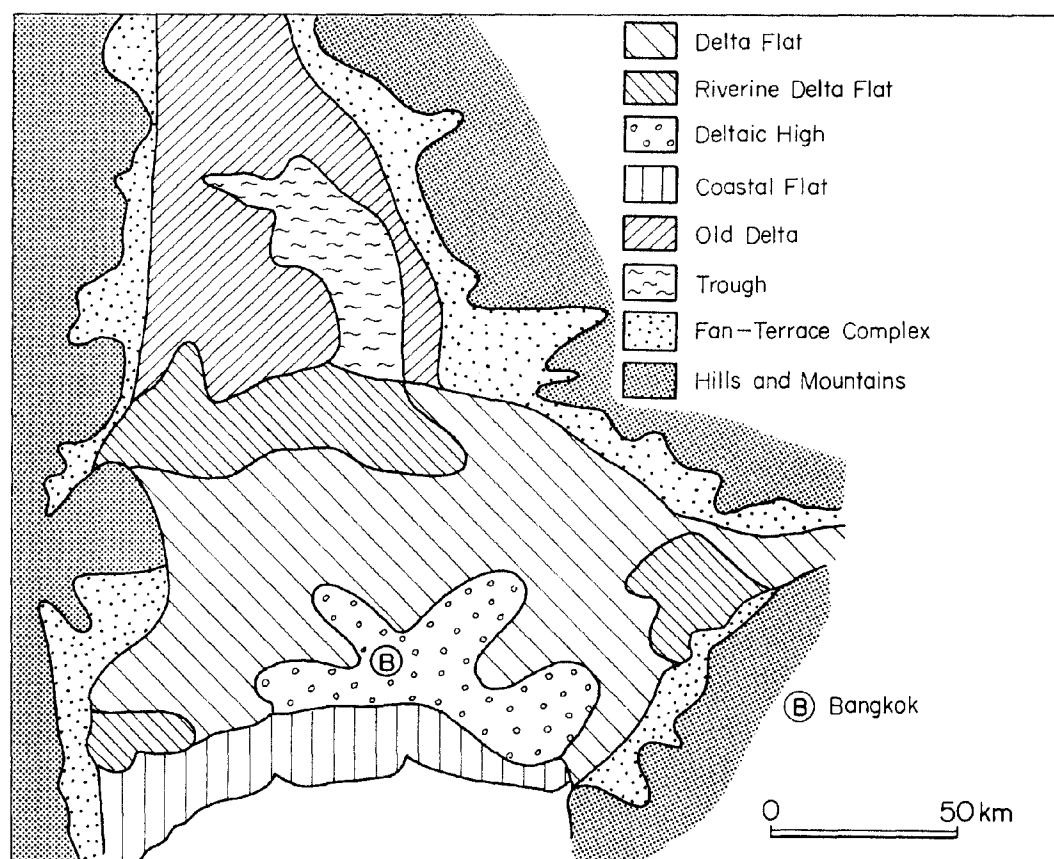


Fig. 4 The physiography of the Chao Phraya delta

based on the height of rice plants.⁷⁾ Similar but slightly different demarcation is given by Kaida⁸⁾ based on the "crop outlook report" of the Royal Irrigation Department.

Deltaic High

An island-like tract having ground elevation higher than 2.5 m, located in the middle of the Chao Phraya delta, is named Deltaic High.^{9)*} This is interpreted to be a complex of levees and old beach ridges. Since this is higher than the surrounding Delta Flat, the monsoon inundation occurs only shallowly. During the dry season, entire area dries up. Soils are mostly composed of non-acid marine alluvial soils.¹⁰⁾

Coastal Flat

Coastal Flat is defined to be a zone sandwiched between Deltaic Flat and the Gulf of Thailand.¹⁰⁾ This area has ground height between 1 to 2 m and is composed of several rows of un conspicuous beach ridge and lagoonal creek which extend parallel to the coast. Because of the area's near-sea position, its hydrography is affected dominantly by tides, and the monsoon flood does not become deep even during its climax stage. Most lagoonal creeks are tidal and suffer from salt water intrusion during the dry season. Soils of beach ridges are sand and loam, while those along creeks are composed of young acid sulphate soils and non-acid marine alluvial soils.¹⁰⁾

Old Delta

Geologically speaking this is a Pleistocene delta. The ground height ranges from 5 m above sea level at the downmost edge to 15 m above sea level at the apex. This is entrenched by many of active and abandoned stream valleys which are a few kilometer wide and 4 to 6 m deep. During the rainy season those entrenching valleys submerge quickly and deeply, leaving the higher level with shallow inundation. During the dry season both the high level and entrenching valleys become dry.

Trough

This is a very broad valley trenching into Old Delta. The dimension is approximately 20 km wide and 50 km long. The ground level is 2 to 5 m lower than the surrounding Old Delta surface.⁹⁾ During the monsoon season, Trough becomes the main drainage channel of the monsoon floods from the upper basin, consequently its flood depth becomes immense in the rainy season. Floods increase their level very quickly and stay very deep for a long period. During dry season, the entire area dries up.

Fan-Terrace Complex

This comprises a merging zone from the delta proper to marginal hills. Geologically this is a complex of fans and terraces encroaching to the delta margin hills. Ground surface

* When Takaya produced a 1 m-contour map based on spot heights shown on the AMS's 1 to 50,000 topographic map,¹¹⁾ an island-like swell having an elevation higher than 2.5 m above sea level appeared in the middle of the delta, and this was named Deltaic High. But a 0.5 m-contour map published by Royal Irrigation Department does not indicate any such swell in the area. Thus the existence of what is called Deltaic High is still problematical.

is higher than 5 m above sea level and stands above the Chao Phraya's flood level. This unit has large general slope and sandy soils, and its catchment area is small. These result in the area's water deficiency. In terms of rice culture this unit is named "water deficient foot hill".¹³⁾ Soils are poor in fertility and often produce many iron concretions and sometimes laterite.

Hills and Mountains

Various kinds of rock, such as sandstone, shale, granitic rocks and Tertiary volcanic rocks occur in the areas. Rice is grown only along narrow stream valleys.

I-2-ii Rice cropping patterns

The situation of rice growing around 1970 is concerned here. There are four important rice cropping patterns in the Chao Phraya deltaic region; they are transplanted main season rice single cropping, broadcast main season rice single cropping, early season rice single cropping and double rice cropping, as shown in Fig. 5 and 6.

Transplanted main season rice single cropping

This cropping pattern is followed on Fan-Terrace Complex, the higher level of Old Delta, Deltaic High, Coastal Flat and a part of Delta Flat. In order to practice this pattern,

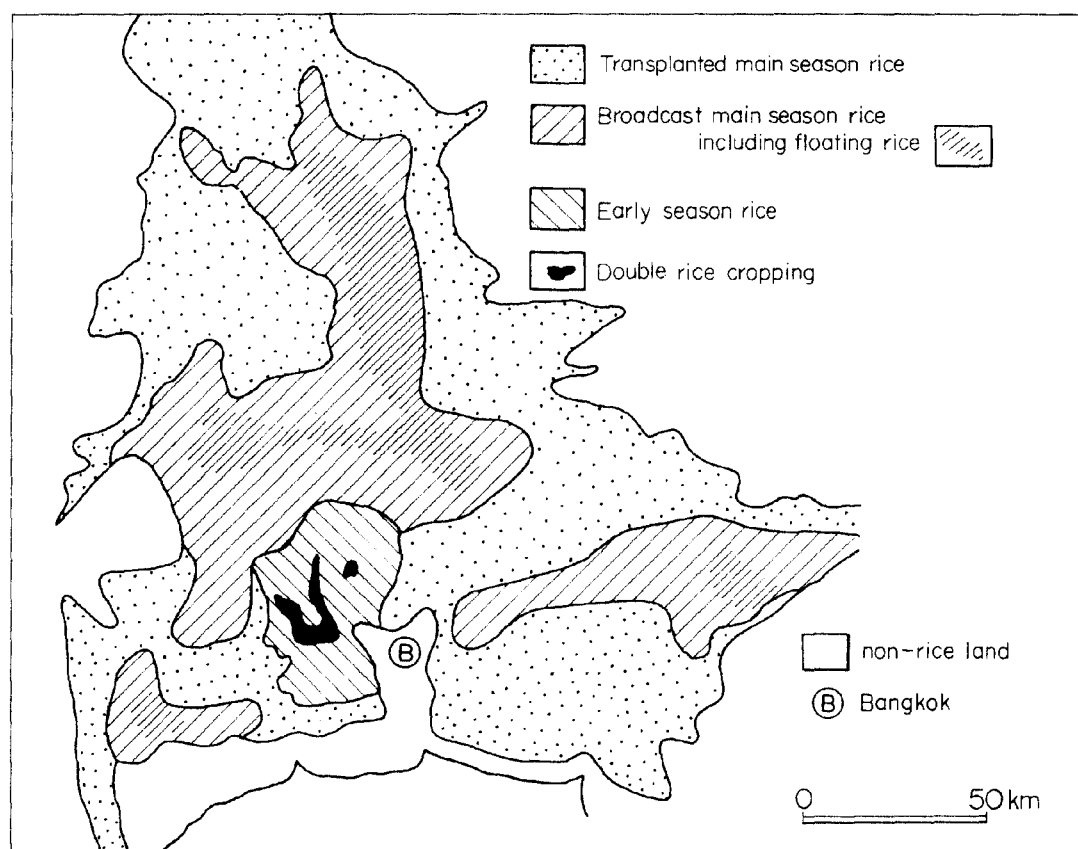


Fig. 5 Rice cropping patterns in the Chao Phraya delta

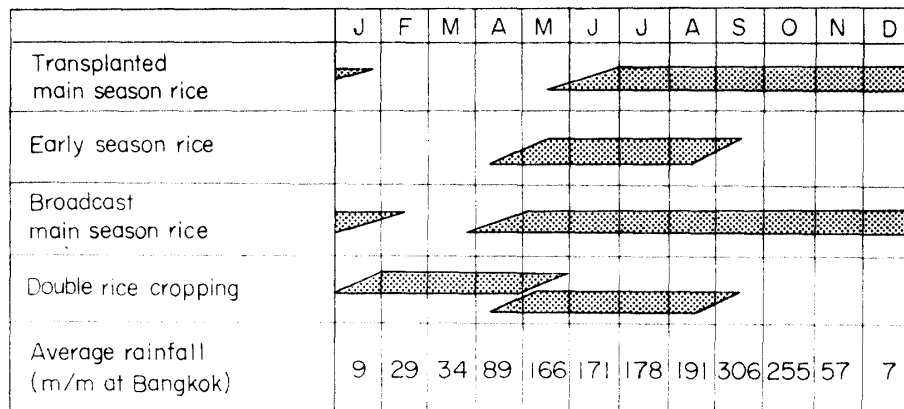


Fig. 6 Rice cropping calendar in the Chao Phraya delta

irrigation is needed during its early growing stage, at least for making nursery. Once the monsoon floods arrive rice plants are in most cases left under the natural flood water. The harvest is made after flood water disappears. There are varieties among transplanted monsoon rice; those on Fan-Terrace Complex and Old Delta are usually of short growth period, while those on Delta Flat, Deltaic high and Coastal Flat are of long growth period.

Early season rice single cropping

This is widely found in the so-called "west bank tract", or the poldered land between the Chao Phraya and the Suphanburi rivers. This tract used to be an area of transplanted main season rice but has been converted to an early season rice area after the execution of the Royal Irrigation Department's water control scheme on the Chao Phraya main stream. In the tract, water is pumped up by lowlift pumps from canals and creeks. Early season rice cannot be grown without irrigation under the existing climatic condition of the area. Harvest is made before monsoon floods become high and harvested fields are left idle all through the monsoon period.

Broadcast main season rice single cropping

Riverine Delta Flat, entrenching valleys of Old Delta and many parts of Delta Flat are covered by this cropping pattern. The areas are characterized by violent flooding of monsoon rain. About one fourth of the total acreage of the broadcast monsoon rice is the so-called floating rice. The practice adopted to these areas are similar to that adopted in the broadcast Aman area of the Ganges-Brahmaputra delta.

Double rice cropping

When irrigation water becomes available throughout the year, double rice cropping is introduced. This cropping pattern is gradually expanding in the west bank tract, and other smaller distributions are also found in some parts of Old Delta as well.

I-3 Mekong Delta

I-3-i Land form

A physiographic map of the Mekong delta is shown in Fig. 7. This is primarily based on the physiographic map of Takaya (1974).¹⁵⁾ The natures of the seven units appeared on the map are briefly described below.

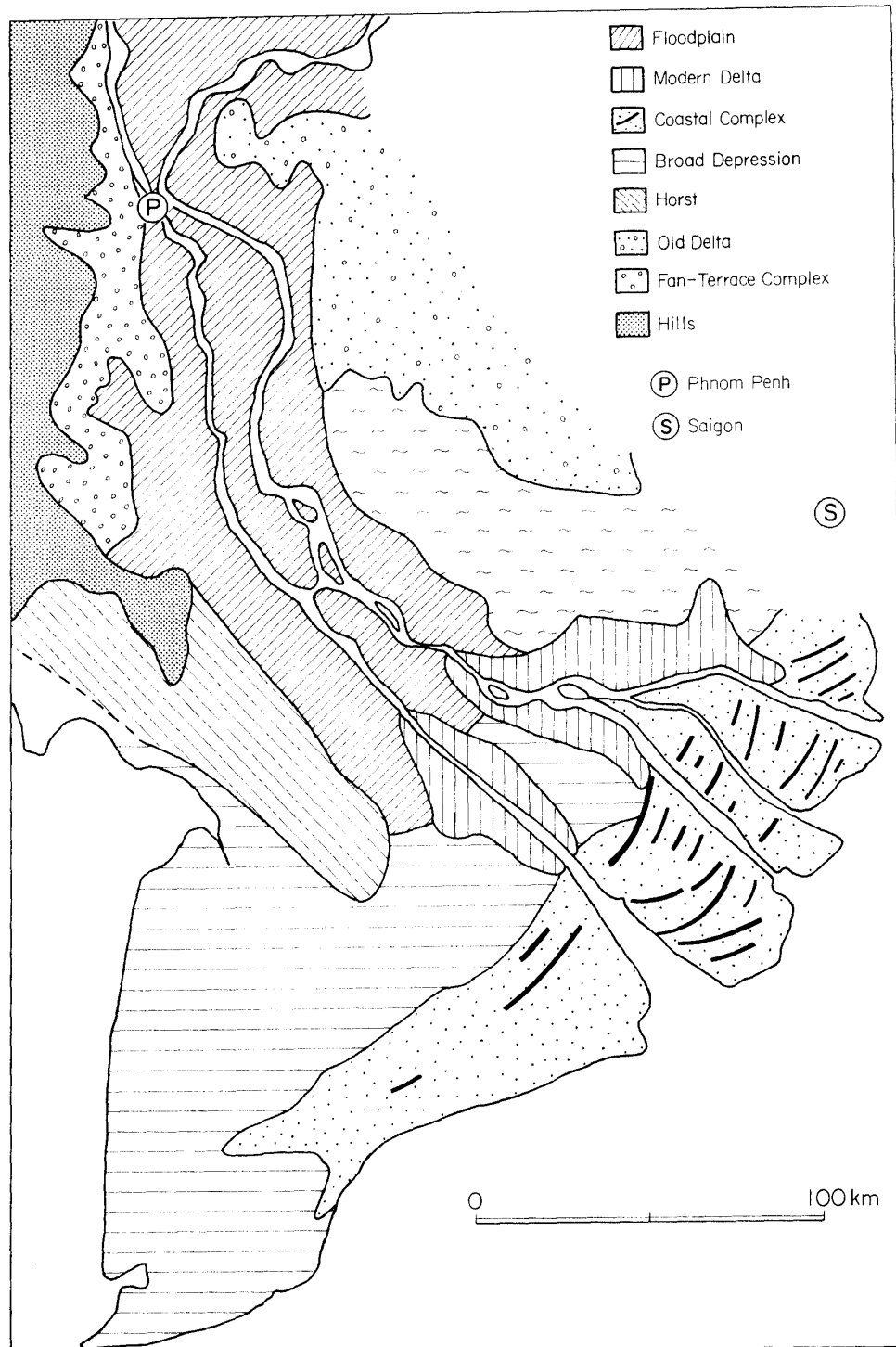


Fig. 7 The physiography of the Mekong delta

Floodplain

Floodplain is composed of levee, sand bar and backswamp. Levee is made of clay loam, sand bar of sand and backswamp of clay. Height difference between a levee and a backswamp may reach 5 m. Floods arrive at Floodplain usually in the middle to end of August. The increase of the flood level is very quick in the Cambodian portion which comprises the upper half of the Floodplain, but relatively slow in the Vietnamese portion where the Floodplain is opened to such broad space as delta proper. Flood depth reaches as deep as 5 to 6 m in the Cambodian portion but remains at about 3 m at the maximum in the Vietnamese portion. During the dry season, the Vietnamese portion dries up entirely but the Cambodian portion keeps numerous swamps and lakes.

Modern Delta

Two major rivers, the Mekong and Bassac, split into many smaller distributaries and form a so-called bird-foot type stream pattern when they come into this area. Since these distributaries are smaller than the Mekong and Bassac in Floodplain, their levees are also smaller than their equivalents in Floodplain; their relative heights from the adjoining backswamps are only 2 m in most cases. Backswamps are also as narrow as 500 m wide. Levees and backswamps are thus small in dimension but occur closely each other and in great number. One of the characteristics of the area is the wide spread of tidal creeks. When monsoon flood comes many parts submerge leaving only levees above water, but the flood depth does not become deep because of this tidal effect.

Coastal Complex

This is composed of three elements, i.e. beach ridge, coastal flat and lagoonal swale.¹⁴⁾ Beach ridge is composed of sand and its maximum elevation attains 5 m above sea level. Lagoonal swale is elongated, parallel to the sea coast and has clayey floor with the elevation as low as 0 m. Coastal flat is flat land lying between a beach ridge and Broad Depression. The soil on coastal flat varies from sand to clay. Coastal Complex has no catchment area from which it can get water, therefore the area tends to be water deficient immediately after the monsoon rain stops. When ground surface dries up salt efflorescence appears in places. Acid sulphate soils appear almost everywhere in lagoonal swale.

Broad Depression

This is originally a saline swamp locked-in by Coastal Complex. Because of this genetic reason, the area is wet or inundated throughout the year and has widely developed acid sulphate soils. Under the existing topographic condition, the bulk of the water of this area is practically separated both from the Mekong and the sea. Water level of Broad Depression rises several tens centimeter in the rainy season, but this is mainly due to rainfall on the spot. Tidal fluctuation is not large except for particular localities which are connected with large tidal creeks.

Horst

This is a flat land located west of Floodplain. This seems to have several tens centimeter higher ground surface than Floodplain, and there is no big rivers in the area. Because of this physiographic condition, monsoon floods come less violently and less deeply than in Floodplain. The border between Horst and Floodplain is conspicuous but the transition from Horst to Broad Depression is gradual.

Old Delta

Old Delta is located on the eastern bank of the Mekong river. The ground surface is flat to slightly undulating and has elevation ranging from about 5 m at the southern end to about 20 m at the northern tip. The ground surface is higher than the monsoon flood level of the Mekong river, so that this area does not suffer flood. But entrenching valleys which are numerous in the area become drainage channels of a part of the Mekong's flood water almost every year.¹⁵⁾ After monsoon rains stop, the terrace level dries up quickly while the entrenching valleys keep water for considerable period.

Fan-Terrace Complex

This is very similar to Fan-Terrace Complex of the Chao Phraya deltaic region. The area comprises sandy terrain which gently slopes toward Floodplain. The monsoon floods cover the area only shallowly for a short period of a year.

Hills

Hills on the west bank are composed of Pre-Tertiary sedimentary rocks. Small paddy fields develop only in stream valleys.

I-3-ii Rice cropping patterns

The rice growing around the year of 1970 is discussed in this chapter. There are four cropping patterns, i.e. transplanted monsoon rice single cropping, broadcast monsoon rice single cropping, double transplanted rice cropping and post-monsoon rice single cropping. Their calendars and distributions are shown in Figs. 8 and 9 respectively.

Transplanted monsoon rice single cropping

This cropping pattern is followed in Broad Depression, Coastal Complex, Old Delta and Fan-Terrace Complex. Of these, Broad Depression and Lagoonal Swale of Coastal Complex are planted to varieties of long growth period. Ploughing may or may not be done before transplanting. In the case of non-ploughing, weeds such as *scirpus* and *cyperus*, are cut by heavy dah and vigorous algae and other aquatic plants are removed by hands, and seedlings as long as more than 1 m are planted in deep water with planting stick. In spite of abundant water in the early rainy season, transplanting must be postponed until August when enough rain water washes salt and acid sulphate out from the area. The varieties of relatively short growth period are found on such well drained areas like Coastal Flat of Coastal Complex, Old Delta and Terrace.

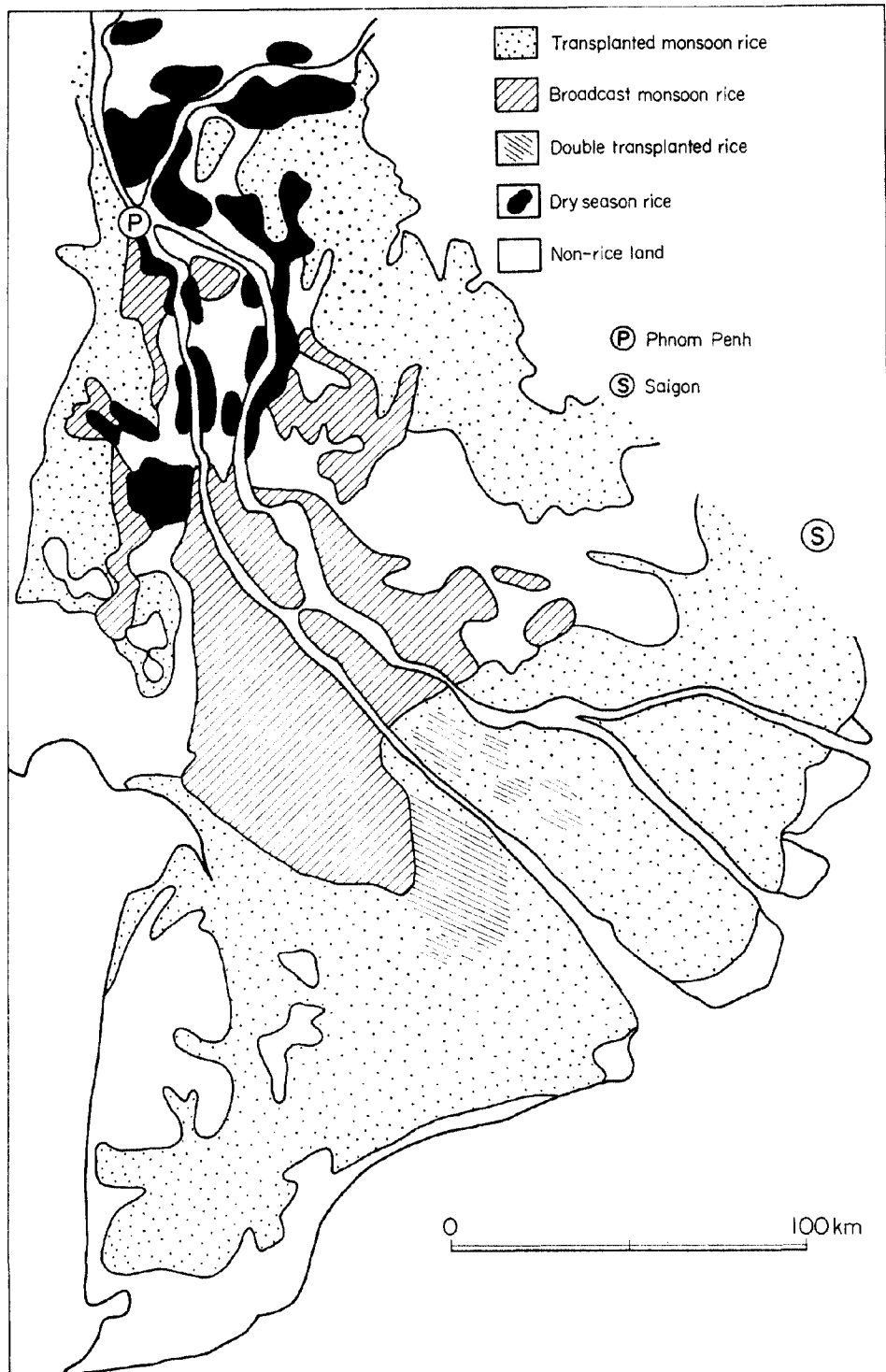


Fig. 8 Rice cropping patterns in the Mekong delta (based on the Netherlands delta development team, 1974)¹⁹⁾

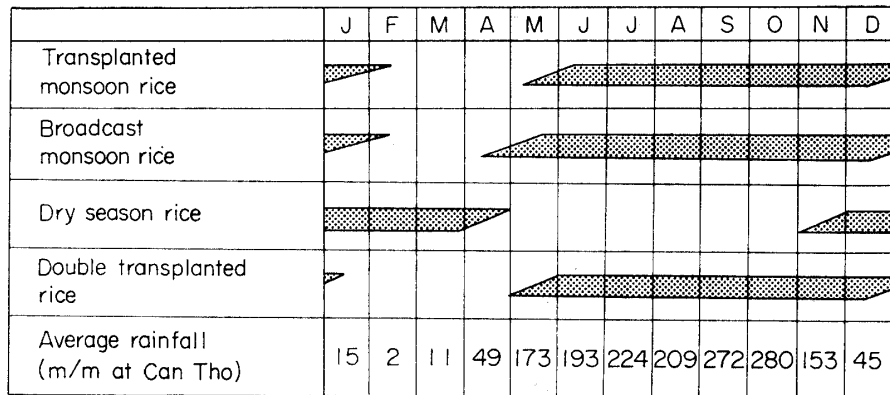


Fig. 9 Rice cropping calendar in the Mekong delta

Broadcast monsoon rice single cropping

The Vietnamese part of Floodplain and Horst are important physiographic units for this rice cropping. Some of the Cambodian part of Floodplain is also grown to this rice. Most of these are so-called floating rice. The practice adopted to these areas are similar to those found in the Brahmaputra and the Chao Phraya deltas.

Double transplanted rice cropping

This is a peculiar growing method to Modern Delta of the Mekong delta. The first nursery is usually prepared on dry land with irrigation at the beginning of rainy season. The area needed for the first nursery is about one fiftieth of the final field. In August seedlings are pulled out and transplanted on the second nursery which is prepared on wet or shallowly inundated plot in swaly portion. The rice plants transplanted in the second nursery produce numerous tillers and grow taller. At the middle of August the monsoon flood level begins to go up and plots ready for the final transplanting gradually increase. Then the final transplanting is begun from the bottoms of backswamp which is the easiest place to get water during early flood season and expands to more poorly watered levee portions with a span of more than one month. Fukui¹⁷⁾ interpreted that the double transplanting is the most suited method adopted to the intricate topographic condition of Modern Delta.

While double transplanted rice is in the first and second nursery, pre-monsoon rice may be grown on well watered portions side by side with nurseries of double transplanted rice. In this case, after the harvest of pre-monsoon rice, the plots which were used for the pre-monsoon rice are immediately converted to the final field of double transplanted rice. According to an unpublished record,¹⁸⁾ pre-monsoon rice (traditional varieties like *Ba Trang*) was planted in Can Tho province in 1965 to an area of 10,000 hectares out of the total rice acreage of 120,000 hectares. Double transplanted rice is thus associated with double rice cropping to some extent.

Dry season rice single cropping

This is found in the Cambodian part of Floodplain. In this part of Floodplain, the monsoon floods are too rough to grow even floating rice, thus the adoption of post-monsoon

rice in receding flood water is the only possible method. This is similar to Boro rice in the Brahmaputra delta. In the Vietnamese part of Floodplain, which is primarily the area of broadcast monsoon rice, post-monsoon rice is occasionally planted to indemnify the losses when abnormally large flood gave sever damage on the monsoon rice.¹⁹⁾

I-4 Songkoi delta

No field study is made by the author in this delta. Everything described below is based on existing records and maps.

I-4-i Land form

The physiography of the Songkoi delta is shown in Fig. 10. This is prepared by the author based on the Aberdeen's physiographic map.²⁰⁾ Six physiographic units, i.e. North Floodplain, West Floodplain, Delta, Coastal Complex, Terrace and Hills, and one man-made unit, i.e. Embankment, are shown here.

North Floodplain

This is an alluvial low land occupying the northern bank of the Songkoi river and the Canal des Rapides. Levees and backswamps develop well. Large flood water comes from hills to the north and this is dammed up by levees, thus the area tends to be inundated deeply

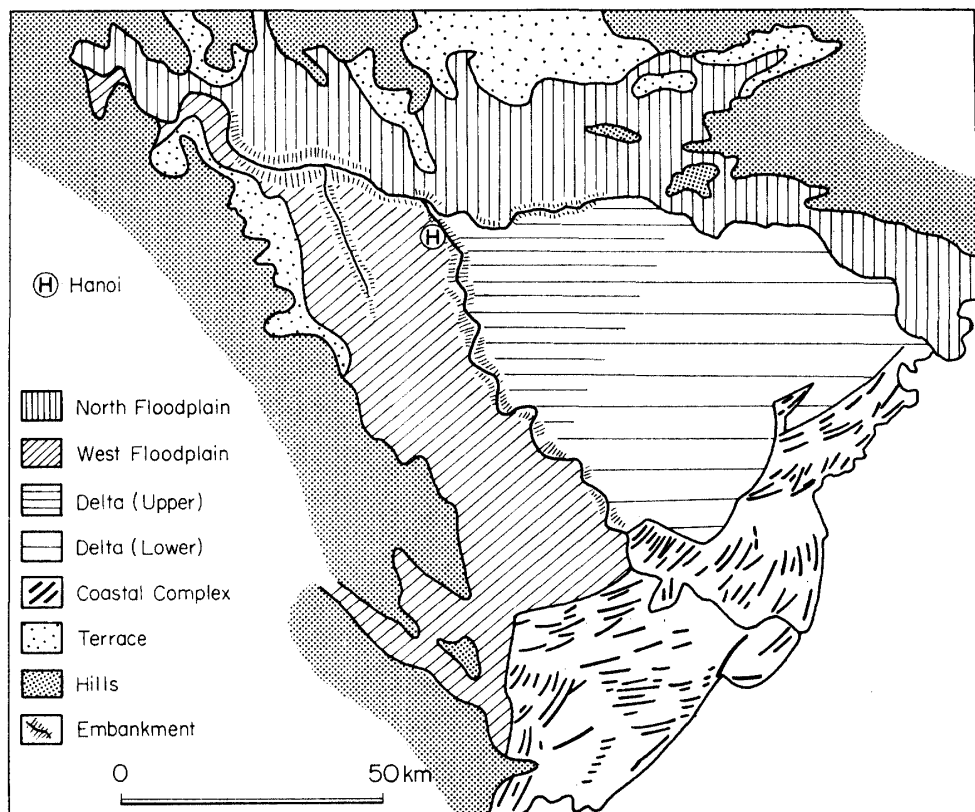


Fig. 10 The physiography of the Songkoi delta

and is difficult to be drained. Acid soils develop in the eastern half of the area, while neutral to slightly acid soils prevail in the western half.²¹⁾

West Floodplain

This is again an alluvial low land with well developed levees and backswamps of active and abandoned Songkoi and the Song Day rivers. The western side of the area is bounded by Terraces and Hills and the eastern side by the Songkoi Embankment which is raised artificially by 6 to 8 m higher than the average ground level of the West Floodplain. The southern end, which is near to the sea, is blocked by a group of beach ridges. Thus Western Floodplain as a whole comprises a hollow like tract enclosed by higher elevations. Because of this topographic character, the area has very poor drainability. According to the soil map of Fridland,²¹⁾ the northern portion is made of rather well drained soils, which merge to poorly drained soils in the middle portion, and in the southern portion the soils further merge to very poorly drained soils like gley-bog soil.

Delta

This is the intertributary area between the Songkoi and the Canal des Rapides. The surface relief is less than those of North and West Floodplains. The area may be described more exactly by dividing it into two subunits, i.e. the upper triangular portion formed by Hanoi-Hung Yen-Sept Pagodes and the lower portion. The upper portion, which may be called Upper Delta has ground elevation higher than 2 m above sea level. This portion gets dry easily during the dry season and is rather well drained even in wet season. The lower portion or Lower Delta, has a lower ground height than 2 m and is characterized by numerous tidal creeks. Although the Fridland's soil map shows no difference in soil characters between Upper and Lower Deltas, it is said that the soil of Lower Delta is more fertile than that of Upper Delta.²⁰⁾ Dominant part are composed of neutral and slightly acid soils of fair drainability. Only in the northeastern corner develops poorly drained acid soil.²¹⁾

Coastal Complex

This is composed of sand ridges and inter-ridge swales. Sand ridges develop most extensively around the mouth of the Songkoi river, where more than 20 ridges 3 to 4 m high are arranged parallel to the coast. The highest ridge usually occurs next to the coast and attains 6 to 7 m high above sea level. Ridges are composed of sandy silt.²⁰⁾ Inter-ridge swales are composed of clay and are affected by sea water if not protected.

Terrace

Ground surface is very slightly undulating and sloped toward the center of the delta. Most area is covered by lateritic soil.²⁰⁾ Entrenching valleys have narrow strips of alluvial soils. Drainability is good on Terrace surface but poor in the entrenching valleys.

Hills

Both north and west hills are composed of pre-Mesozoic sedimentary rocks. Paddy fields occur only in small stream valleys.

Embankment

The Songkoi delta is distinctively characterized by its well developed man-made embankments. Figuratively speaking, the whole part of the delta is poldered in by those embankments. A typical cross-section of the embankment of the Songkoi river near Hanoi is shown in Fig. 11. Repeated reinforcement and the raising of height of the embankment is clearly illustrated in the figure. The confinement of the flood water within the high banks resulted in the raising of the height of flood level. It is reported that during the record high flood of 1945, the flood level of the Songkoi river was 7.0 m higher than the average ground level of the surrounding paddy field at Son Tay, 7.5 m higher at Hanoi and 6.0 m higher at Hung Yen.²²⁾ Owing to this large head, damage by flood is disastrous once a breach occurs. Breach currents cause scouring of ground and transform several areas into ponds and barren sand accumulations. It is a matter of common knowledge that floods of the Songkoi delta bring destruction and poverty. This makes a very good contrast to the situation common in most of major deltas in Southern Asia where floods are supposed to be beneficial.

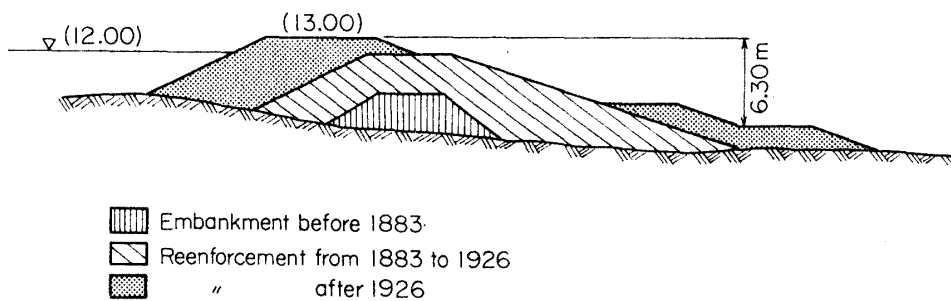


Fig. 11 A typical cross-section showing successive enforcement of the embankment of the Songkoi river near Hanoi

Although breach floods rage in all fury, they usually drain quickly. For instance, in the case of the record flood of 1945, fourteen breaches occurred on the embankments of the Songkoi river during the period of August 16 and 22, and 230,000 hectares of rice land were destroyed, but more than half of this area was planted out to tenth-month crop (harvested in November to December of the same year) again. Floods in the Songkoi delta are flush type in character.

I-4-ii Rice cropping patterns

The state of rice growing around 1930 is described here.

In the Songkoi delta, there are three kinds of rice cropping patterns as shown in Fig. 12; they are tenth-month rice single cropping, fifth-month rice single cropping and double rice cropping. The distributions are shown in Fig. 13.

Tenth-month rice single cropping

Tenth-month rice is the North Vietnamese version of transplanted monsoon rice. The name comes from the fact that the rice is harvested in the tenth month of lunar calendar, which

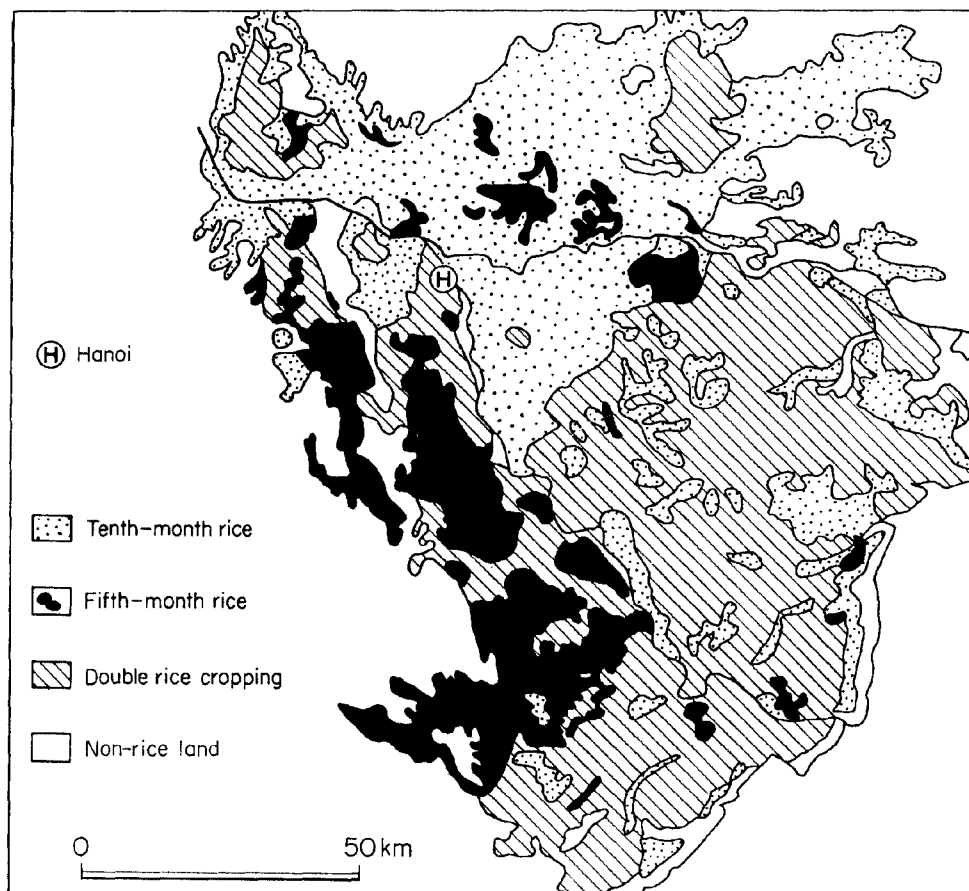


Fig. 12 Rice cropping patterns in the Songkoi delta around 1930, cited from Gourou, P. (396p.)²⁴⁾

	J	F	M	A	M	J	J	A	S	O	N	D
Tenth-month rice												
Fifth-month rice												
Double rice cropping												
Average rainfall (m/m at Hanoi)	18	29	39	79	193	234	322	333	248	116	44	18

Fig. 13 Rice cropping calendar in the Songkoi delta

roughly corresponds to December in solar calendar. The cropping pattern is found on Terrace, Northern Floodplain, Upper Delta and some portion of Coastal Complex. These are all well drained area and do not have enough water to grow rice during dry season.

Fifth-month rice single cropping

This cropping pattern is followed in West Floodplain and swales in North Floodplain.

In these areas the monsoon floods are so unstable and sometimes become so deep that rice growing during the flood period is impossible. Rice is grown in the receding water with supplementary irrigation. This is a kind of post-monsoon rice.

Double rice cropping

This pattern is followed in Lower Delta and Coastal Complex. Most of the double cropping areas are said to have been once the land of tenth-month rice land. Building of irrigation installations by local farmers have achieved the transformation of the area from one cropping land to the double cropping land. Double cropping area which is originated from fifth-month rice area is not common if not negligible. There is another type of double cropping area in North Floodplain and its adjoining Terrace areas. These were formally the tenth-month rice area but converted to double cropping land after the government constructed barrages on rivers such as Song Cau and Song Thong.

II Model Analysis

II-1 Monsoon climate

Southeast Asia is characterized by monsoon climate. When the period having monthly rain fall over 200 mm is defined as monsoon season. Monsoon season lasts for three months from June to August at Jessore in the Ganges-Brahmaputra delta, for two months of September and October at Bangkok in the Chao Phraya delta, for four months from July to October at Can Tho in the Mekong delta and for four months from June to September at Hanoi in the Songkoi delta, respectively. Although the period and duration of the monsoon season vary from place to place, the cyclic pattern of dry season and rainy season is common throughout the region. The cycle may be divided into pre-monsoon period, monsoon period and post-monsoon period as shown in Fig. 14.

II-2 Land form of delta region

A physiographic model of delta may be illustrated as shown in Fig. 15. A delta may have at most six land form units, i.e. Flood Releasing Area, Floodplain, Young Delta, Coastal Zone, Old Delta and Local Swale.

Flood Releasing Area comprises terraces and hills. This has higher ground elevation and sloped ground surface toward the center of the delta, therefore monsoon rain water drains out quickly from the area causing only shallow and casual inundation.

Floodplain and *Young Delta* are flood-receiving areas. All the water within the drainage basin drains to these places, so that their inundations are deep and prolonged. Particularly in Floodplain, which extends along major rivers, the rate of increase of flood depth is very rapid due to the accumulation of run-off from the upper reaches. The maximum flood depth may reach to 3 m or more in Floodplain, while it remains less than 1 m in most part of Young Delta. Both Floodplain and Young Delta dry up during dry season.

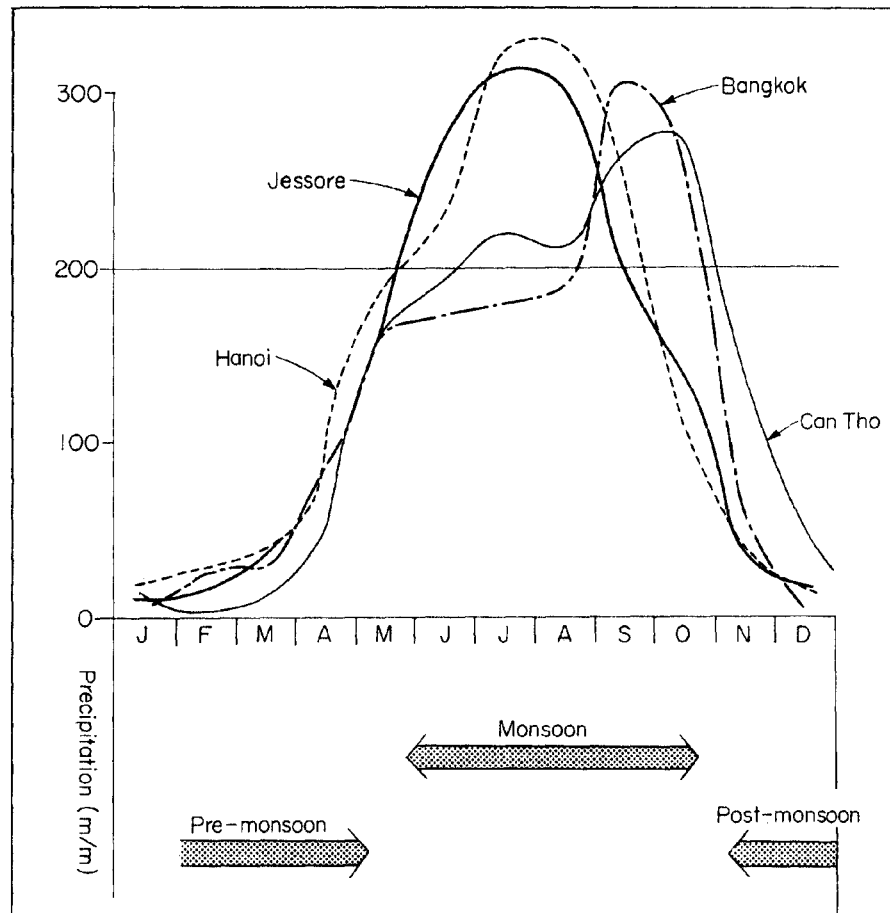


Fig. 14 A diagram showing the monsoonal character of Southeast Asian climate

Old Delta has flat to slightly undulating ground surface whose average elevation is a few meter higher than the adjoining Floodplain and Young Delta. Because of this higher elevation monsoon floods usually stay on the area with medium to shallow depths for relatively short period. Only local depressions like entrenching valleys submerge under floods very deeply for a prolonged period.

Coastal Zone comprises complex of raised beach ridges and inter-beach ridge swales. Monsoon flood levels never reach to the height of beach ridge. Some of swales are as low as sea level and keep water even during dry season. Part of Coastal Zone suffers from salt and acid sulphate injuries.

Local Swale forms patches within Floodplain or occasionally along entrenching valleys in Old Delta and other places. These are local depressions in which flood water accumulates. The rate of increase of flood level is extraordinary large and its maximum depth also becomes very deep. Some parts may remain as ponds or swamps even during dry season.

II-3 Rice cropping patterns

Transplanted monsoon rice single cropping, broadcast monsoon rice single cropping, pre-

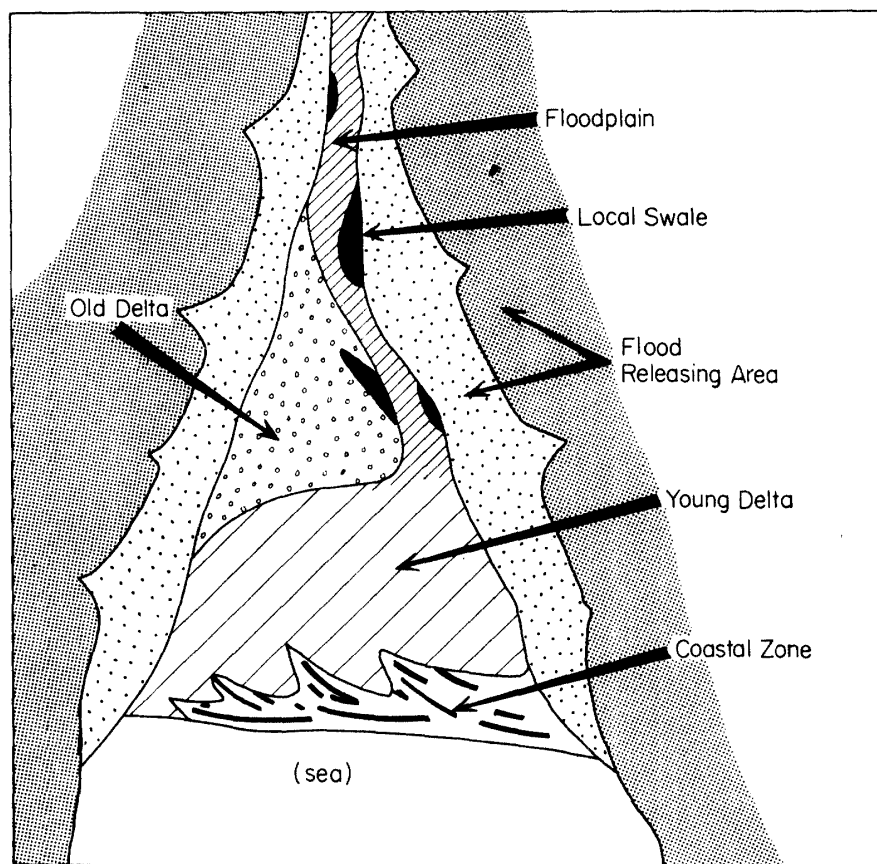


Fig. 15 A Physiographic model of delta commonly adoptable to major deltas in Southeast Asia

monsoon rice single cropping, post-monsoon rice single cropping and double rice cropping are major rice cropping patterns in Southern Asia. The relationship of these rice cropping patterns and land forms are summarized as below.

Transplanted monsoon rice single cropping

This pattern is followed in areas where fresh water is available only in monsoon season. There are four land form units adopting this pattern, i.e. Flood Releasing Area, Old Delta, Coastal Zone and a part of Young Delta. In the low level of Coastal Zone, water may remain there throughout the year, but it is often toxic during dry season due to contamination of acid sulphate and salt, which hinders the rice growing of the dry season.

Broadcast monsoon rice single cropping

Broadcast monsoon rice single cropping is followed in Floodplain. In Floodplain, the coming of monsoon flood is so unstable; the time of arrival fluctuates greatly from year to year and once it arrives it increases the depth very rapidly in a short period. Under such condition, transplanting cannot be practiced. Only way to cope with the environment is to prepare sufficiently long and strong rice plants well in advance in fields so that the plants can take the chance of survival when the floods come. A part of Young Delta is also the place of

Broadcast rice. In this area, the crucial hindrance for transplanting is not the rapid increase of flood level but the lack of water in making nursery during early monsoon season. If the terrain has a sufficient relief to make local pools or if net worked by canals, farmers would be able to prepare nursery in early monsoon season depending on those local water sources. But in fact the part of Young Delta of this season is just an immense expanse of dry flat land, and making nursery is impossible.

Pre-monsoon rice single cropping

Where the pre-monsoon precipitation is considerably high, pre-monsoon rice is often grown with supplementary irrigation in places along water courses, regardless the physiographic unit. A typical example is seen in the Brahmaputra delta, where pre-monsoon rainfall is dependable. The Chao Phraya's West Bank tract is another type of example. Here the climatic condition is not favorable but canals were dug and irrigation water became available, thus pre-monsoon rice replaced traditional monsoon rice. In both cases, pre-monsoon rice acreage has increased greatly in the last several years thanks to the introduction of superior non-photo sensitive varieties of rice like IRRI varieties.

Post-monsoon rice single cropping

In those areas where the behavior of monsoon flood is extraordinarily violent with very sharp rising of flood level and too great maximum depth, no rice can survive during monsoon time. In such a case rice must be grown avoiding flood season. Rice cultivation in Local Swale belongs to this case. Rice is planted around the edges of slowly drying pools and streams during the end of flood season. This is the original type of post-monsoon rice. After the introduction of the IRRI varieties, new type of post-monsoon rice growing has been expanding remarkably with the help of pumps.

Double cropping

Post-monsoon rice and the pre-monsoon rice with pump irrigation are almost synonymous with multi-rice cropping. Because once farmers could manage to secure water for pre- or postmonsoon rice, it is already easy business for them to grow two crops of rice a year. The most common patterns of double cropping are 1) pre-monsoon rice plus post-monsoon rice and 2) pre-monsoon rice plus monsoon rice. The former is commonly seen in Floodplain and the latter in Young Delta. The limiting factor for the expansion of double cropping is the insufficient volume of low flow in major rivers which is the source of irrigation water for dry season cropping.

III Correlation

A correlation of rice cropping patterns in the four deltas concerned is tabulated as below.

*Transplanted monsoon rice**

* categorized pattern of rice cropping

Brahmaputra:

- transplanted Aman rice* on Flood Releasing Area** (Himalayan Alluvial Plain,***
 (high level of Sylhet Basin,
 Hills and Mountains)
- " on Young Delta (high level of West Moribund Delta and
 East Moribund Delta)
- " on Coastal Zone (Tidal Zone)
- " on Old Delta (Barind Terrace)

Chao Phraya:

- transplanted main season rice on Flood Releasing Area (Fan-Terrace Complex and
 Hills and Mountains)
- " on Old Delta (Old Delta)
- " on Coastal Zone (Coastal Flat)
- " on irrigated Young Delta (irrigated part of Delta
 Flat and Deltaic High)

Mekong:

- transplanted monsoon rice on Flood Releasing Area (Fan-Terrace Complex,
 Hills and Mountains)
- " on Old Delta (Old Delta)
- " on Coastal Zone (Broad Depression and Coastal Complex)

Songkoi:

- tenth-month rice on Flood Releasing Area (Hills and Mountains)
- " on Coastal Zone (Coastal Complex)
- " on a part of Young Delta (Upper Delta and
 a part of Lower Delta)
- " on a part of Floodplain (a part of North Floodplain and
 a part of West Floodplain)

Broadcast monsoon rice

Brahmaputra:

- broadcast Aman rice on Floodplain (Ganges-Brahmaputra Floodplain and
 middle level of Sylhet Basin)
- " on Young Delta (lower level of West Moribund Delta)

Chao Phraya:

- broadcast main season rice on Floodplain (Trough)
- " on non-irrigated Young Delta (Riverine Delta Flat and
 non-irrigated Delta Flat)
- " on lowre level of Old Delta (entrenching valleys)
 in Old Delta)

* local name of rice cropping pattern
 ** land form in schematized delta model
 *** local name of land form

Mekong:

broadcast monsoon rice on Floodplain (Floodplain)

“ on non-irrigated Young Delta (Horst)

Songkoi:

negligible

Pre-monsoon rice

Brahmaputra:

Aus rice on various places where either irrigation water or natural moisture is sufficient during pre-monsoon period

Chao Phraya:

Early monsoon rice on irrigated Young Delta (poldered part of Delta Flat like “West Bank” and other irrigated patches in Delta Flat)

Mekong:

negligible

Songkoi:

negligible

Post-monsoon rice

Brahmaputra:

Boro rice on Local Swale (lower levels of Sylhet Basin, entrenching valleys within Barind Terrace and Madhupur Jungle)

Chao Phraya:

none

Mekong:

Dry season rice on Local Swale (Cambodian portion of Floodplain)

Songkoi:

Fifth-month rice on Local Swale (Lower level of West and North Floodplains)

Double rice cropping

Brahmaputra:

on scattered fields with polder dikes in East and West Moribund Deltas and the marginal parts of Ganges-Brahmaputra Floodplain

Chao Phraya:

on irrigated patches in Young Delta (Delta Flat) and Old Delta (Old Delta), 1970

Mekong:

negligible in 1970, and on irrigated patches in Young Delta (Modern Delta) and Floodplain (pump-irrigated patches in Vietnamese part of Floodplain) in 1974

Songkoi:

on irrigated plots in Young Delta (Lower Delta), Coastal Zone (Coastal Complex) and Terrace (north of North Floodplain), in 1930

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